deed, no proper submucous, areolar tissue, the membrane being applied directly to the uterine walls. It is covered by a single layer of cylindrical epithelial cells, with delicate cilia, the movements of which are from without inward, toward the openings of the Fallopian tubes. Examination of the surface of the membrane with a low magnifying power shows the openings of a great number of tubular glands. These glands usually are simple, sometimes branched, dividing, about midway between the opening and the lower extremity, into two and very rarely into three secondary tubules. Their course generally is tortuous, so that their length frequently exceeds the thickness of the mucous membrane. The openings of these tubes are about $\frac{1}{350}$ of an inch (72 μ) in diameter. Their secretion, which forms a thin layer of mucus on the surface of the membrane in health, is grayish, viscid and feebly alkaline. The tubes themselves have very thin, structureless walls and are lined with cylindrical, ciliated epithelial cells.

The changes which the mucous membrane of the body of the uterus undergoes during menstruation are remarkable. Under ordinary conditions its thickness is $\frac{1}{25}$ to $\frac{1}{14}$ of an inch (1 to 1·8 mm.); but it measures during the menstrual period $\frac{1}{6}$ to $\frac{1}{4}$ of an inch (4·2 to 6·4 mm.).

In the cervix the membrane is paler, firmer and thicker than the membrane of the body of the uterus, and between these two mucous surfaces there is a distinct line of demarkation. It is more loosely attached to the subjacent tissue, in the cervix, and the anterior and posterior surfaces of the neck present an appearance of folds radiating from the median line, forming what has been called the arbor vitæ uteri, or plicæ palmatæ. Throughout the entire cervical membrane, are mucous glands, and in addition, in the lower portion, are a few rounded, semi-transparent, closed follicles, called the ovules of Naboth, which are cystic enlargements of obstructed follicles. The upper half of the cervical membrane is smooth but the lower half presents a large number of villi. The epithelium of the cervix presents great variations in its character in different individuals. Before the time of puberty the entire membrane of the cervix is covered with ciliated epithelium. After puberty, however, the epithelium of the lower portion changes its character, and there are cylindrical cells above, with squamous cells in the inferior portion. The latter extend upward in the neck, to a variable distance.

The blood-vessels of the uterus are very large and present certain important peculiarities in their arrangement. The uterine arteries pass between the layers of the broad ligament, to the neck, and then ascend by the sides of the uterus, presenting a rich plexus of vessels, anastomosing above with branches from the ovarian arteries, sending branches over the body of the uterus, and finally penetrating the organ, to be distributed mainly in the middle layer of muscular fibres. In their course these vessels present a convoluted arrangement and form a sort of mould of the body of the uterus. Rouget has called this the erectile tissue of the internal generative organs. It lacks, however, certain of the characters of true, erectile tissue. By placing the pelvis in a bath of warm water and injecting what he called the

spongy bodies of the ovaries and uterus, by the ovarian veins, he produced a distention of the vessels and a sort of erection, the uterus executing a movement upward.

In the muscular walls of the uterus, are large veins, the walls of which

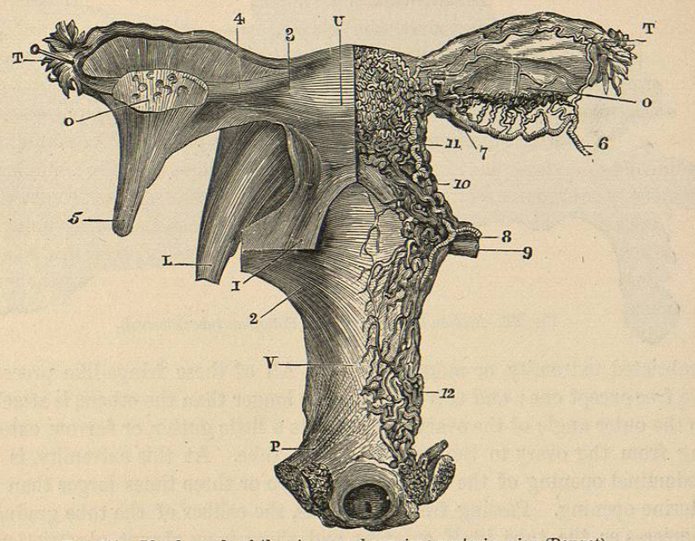

FIG. 281.—*Blood-vessels of the uterus and ovaries; posterior view* (Rouget).

T, T, Fallopian tubes; O, O, ovaries; U, uterus; V, vagina; P, pubis; L, anterior round ligament; 1, 2, muscular fibres of the vagina; 3, 4, ligament of the ovary; 5, superior round ligament; 6, ovarian artery; 7, ovarian vein; 8, uterine artery; 9, uterine vein; 10, 11, uterine plexus; 12, vaginal plexus.

are closely adherent to the uterine tissue. During gestation these vessels become enlarged, forming the so-called uterine sinuses.

Lymphatics are not very abundant in the unimpregnated uterus, but they become largely developed during gestation. They exist in a superficial and a deep layer, the deeper vessels being connected with lymph-spaces in the muscular walls and in the mucous membrane.

The uterine nerves are derived from the inferior hypogastric and the spermatic plexuses, and the third and fourth sacral. In the substance of the uterus they present in their course small collections of ganglionic cells, and it is said that the nerves pass finally to the nucleoli of the muscular fibres (Frankenhaeuser).

The Fallopian Tubes.—The Fallopian tubes, or oviducts, lead from the ovaries to the uterus. They are shown in Fig. 275. These tubes are three to four inches (7·6 to 10·1 centimetres) long, but their length is not always equal upon the two sides. They lie between the folds of the broad ligament, at its upper border. Opening into the uterus upon either side at the cornua, they present a small orifice, about $\frac{1}{25}$ of an inch (1 mm.) in diameter. From the cornua they take a somewhat undulatory course outward, gradually increasing in size, so that they are rather trumpet-shaped. Near the ovary

they turn downward and backward. The extremity next the ovary is marked by ten to fifteen fimbriæ, or fringes, which have given this the name of the

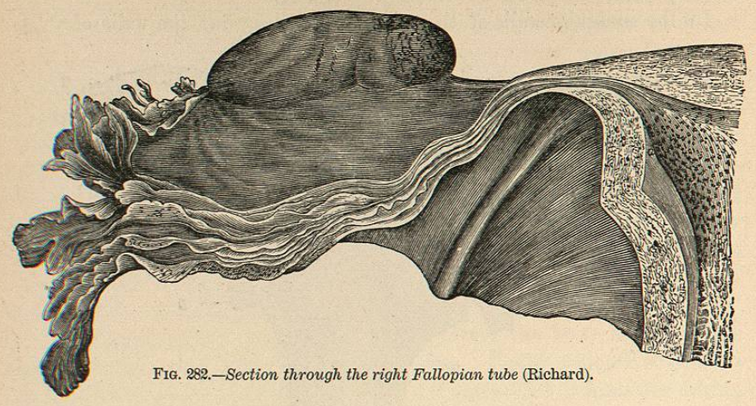

Fig. 282.—*Section through the right Fallopian tube* (Richard).

fimbriated extremity, or morsus diaboli. All of these fringe-like processes are free except one; and this one, which is longer than the others, is attached to the outer angle of the ovary and presents a little gutter, or furrow, extending from the ovary to the opening of the tube. At this extremity, is the abdominal opening of the tube, which is two or three times larger than the uterine opening. Passing from the uterus, the caliber of the tube gradually increases as the tube itself enlarges, and there is an abrupt constriction at the abdominal opening.

Beneath the peritoneal coat, which is formed by the layers of the broad ligament, is a layer of connective tissue, containing a rich plexus of blood-vessels. This constitutes the proper, fibrous coat of the Fallopian tubes.

The muscular layer is composed mainly of circular fibres of the non-striated variety, with a few longitudinal fibres prolonged over the tube from the external, muscular layer of the uterus. This coat is quite thick and sends bands between the layers of the broad ligament, to the ovary.

The mucous membrane of the tube is thrown into folds, which are longitudinal and transverse near the uterus and are more complicated at the dilated portion. In this portion, next the ovary, embracing about the outer two-thirds, the folds project far into the caliber of the tube. These are sometimes simple, but more frequently they present secondary folds, often meeting as they project from opposite sides. This arrangement gives an arborescent appearance to the membrane on transverse section of the tube. The mucous membrane is covered by cylindrical ciliated epithelium, the movement of the cilia being from the ovary toward the uterus. The membrane of the tubes has no mucous glands.

It is not necessary to give a minute description of the external organs of the female. Opening by the vulva externally, and terminating at the neck of the uterus, is a membranous tube, the vagina. This lies between the bladder and the rectum. It has a curved direction, being $3\frac{1}{6}$ to $3\frac{1}{2}$ inches (8 to 9

Plate I.

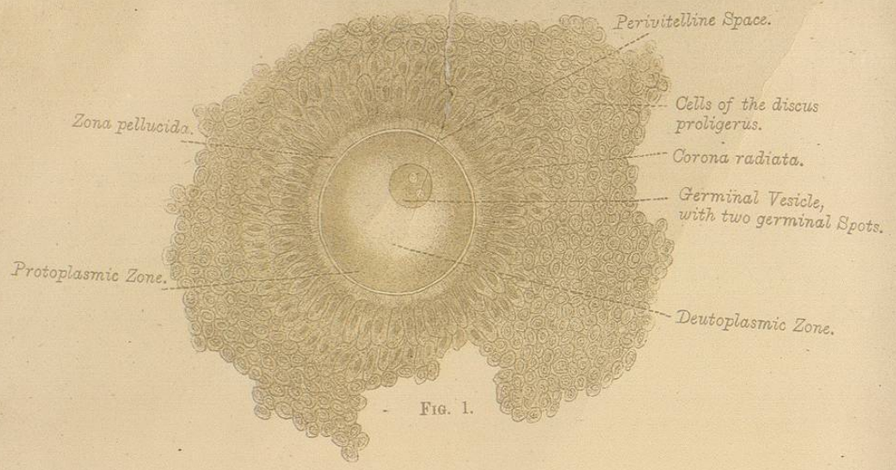

FIG. 1.

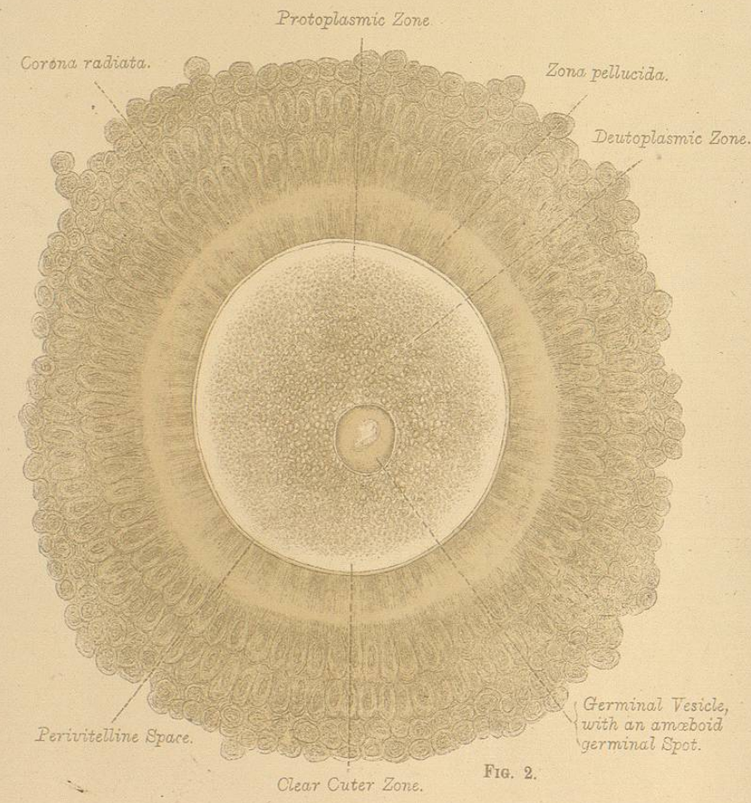

FIG. 2.

FIG. 1.—Deutoplasm-forming ovum from a Graafian follicle of a woman 27 years old (Nagel).

FIG. 2.—Fresh ovum from Graafian follicle of a woman 30 years old; slightly reduced from the original figure (Nagel).

centimetres) long in front, and 3½ to 4 inches (9 to 10 centimetres) long posteriorly (Sappey). At the constricted portion of the outer opening, there is a muscle, called the sphincter vaginæ, and the tube is somewhat narrowed at its upper end, where it embraces the cervix uteri. The inner surface presents a mucous membrane, marked by transverse rugæ, with papillæ and mucous glands. Its surface is covered with flattened epithelium. The vagina is quite extensible, as it must be during parturition, to allow the passage of the child. It presents a proper coat of dense, fibrous tissue, with longitudinal and circular muscular fibres of the non-striated variety. Surrounding it, is a rather loose, so-called erectile tissue, which is most prominent at its lower portion.

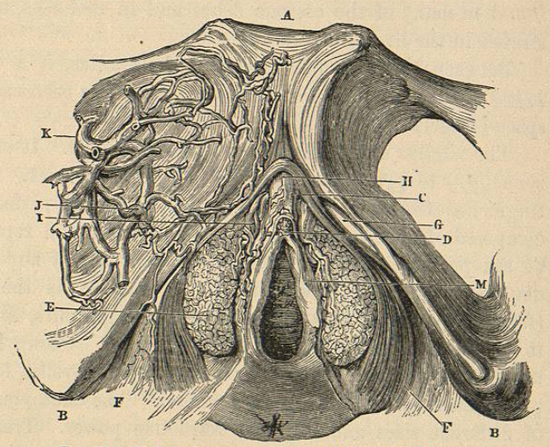

FIG. 283.—*External erectile organs of the female* (Liégeois).
A, pubis; B, B, ischium; C, clitoris; D, gland of the clitoris; E, bulb; F, constrictor muscle of the vulva; G, left pillar of the clitoris; H, dorsal vein of the clitoris; I, intermediary plexus; J, vein of communication with the obturator vein; K, obturator vein; M, labia minora.

The parts composing the external organs are abundantly supplied with vessels and nerves. In the clitoris, which corresponds to the penis of the male, and on either side of the vestibule, there is a true erectile tissue.

Structure of the Ovum.—The description which is to follow is based upon recent and extended researches into the minute anatomy of the healthy human ovum (Nagel, 1888), which have been rendered possible by the frequency with which, within the past few years, normal ovaries are removed in surgical operations:

The ovum lies in the Graafian follicle, embedded in the mass of granular cells which form the discus proligerus. Surrounding the ovum are cells similar to those found in other parts of the membrana granulosa, and two or three layers of columnar cells, the latter lying next the zona pellucida. These columnar cells constitute the corona radiata (Bischoff). The ovum itself presents the following structures: (1) Zona pellucida; (2) perivitelline space; (3) a clear, outer zone of the vitellus; (4) protoplasmic zone (formative yelk); (5) deutoplasmic zone (nutritive yelk); (6) germinal vesicle (Purkinje); germinal spot (Wagner). The extremely thin membrane within the zona pellucida and immediately surrounding the vitellus, described under the name of vitelline membrane by some anatomists, was not observed by Nagel in the human ovum.

The ovum is globular, with a diameter of about $\frac{1}{150}$ of an inch (165 to 170 μ) measured from the outer border of the zona pellucida.

The zona pellucida (zona radiata, or vitelline membrane) is $\frac{1}{1250}$ to $\frac{1}{1000}$ of an inch (20 to 24 μ) in thickness. It is a strong membrane appearing in the form of a clear zone in the mass of surrounding cells. It is marked by striæ, which are thought by some anatomists to indicate the presence of small pores; but the large, single opening called a micropyle, which is found in many of the osseous fishes and in mollusks, has not been demonstrated in the human ovum.

Between the zona pellucida and the vitellus, is a narrow space, about $\frac{1}{20000}$ of an inch (1·3 μ) in diameter. This has been called the perivitelline space (Nagel).

The vitellus is contained in the zona pellucida. It presents a clear, outer zone $\frac{1}{6000}$ to $\frac{1}{4000}$ of an inch (4 to 6 μ) in diameter. This can not be distinguished from the protoplasmic zone, except in perfectly fresh ova. It is composed of clear protoplasm without granules and represents that portion of the protoplasm of the vitellus which is not at any time converted into deutoplasm (Nagel). Within the clear zone, is the protoplasmic zone (formative yelk). This presents very fine granules, and the zone is $\frac{1}{2500}$ to $\frac{1}{1200}$ of an inch (10 to 21 μ) in thickness. Occupying the central portion of the vitellus, is the deutoplasm (nutritive yelk), forming a mass about $\frac{1}{300}$ of an inch (82 to 87 μ) in diameter. The deutoplasm presents granules of different sizes and different refractive power. Treated with eosin, the protoplasm becomes rose-colored, but the deutoplasm is unaffected. As the ovum reaches its final stage of development, the protoplasmic zone, as far as that portion which forms the so-called outer zone, is gradually changed into deutoplasm. In Plate II, Fig. 1, an ovum is represented in which this change is in progress.

The germinal vesicle lies always in the protoplasmic zone, just outside of the deutoplasm. As the mass of deutoplasm extends, the germinal vesicle is pushed toward the periphery of the vitellus. The vesicle measures about $\frac{1}{1000}$ of an inch (25 to 27 μ) in diameter. It is globular, with a double contour. In hardened preparations, it presents a frame-work of fine anastomosing fibres. In the fully developed human ovum, no amœboid movements have as yet been observed in the germinal vesicle (Nagel). In Plate II, Fig. 2, the germinal vesicle is seen lying upon and not within the deutoplasmic zone. The mature ovum presents but one germinal vesicle. Two germinal vesicles, however, are sometimes found in primordial ova (see Fig. 284).

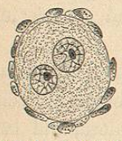

Fig. 284.—*Primordial ovum with two germinal vesicles and follicular epithelium; from the ovary of a new-born child* (Nagel).

The germinal spot (Wagner) is contained in the germinal vesicle. Some vesicles present two germinal spots. In perfectly fresh ova, the germinal spots have been observed to undergo amœboid movements.

Discharge of the Ovum.—A ripe Graafian follicle measures $\frac{2}{3}$ to $\frac{1}{2}$ of an inch (10 to 12 mm.) in diameter, and presents a rounded elevation, containing a plexus of blood-vessels, upon the surface of the ovary. At its most prominent portion, is an ovoid spot in which the membranes are entirely free from blood-vessels. At this spot, which is called the macula folliculi, the coverings finally give way and the contents of the follicle are discharged. For a short time anterior to the rupture of the follicle, important changes have been going on in its structure. In the first place, the non-vascular portion situated at the very surface of the ovary undergoes fatty degeneration, by which this part of the wall gradually becomes weakened. At the same time, at the other portions of the follicle, there is a proliferation of cells which project into the interior, and an extension, into the interior, of blood-vessels in the form of loops. These changes, with an increase in the pressure of liquid and the fatty degeneration of the macula, cause the follicle to burst; and with the liquid, the discus proligerus and the ovum are expelled. The formation of a cell-growth in the interior of the follicle is the beginning of the corpus luteum; and this occurs some time before the discharge of the ovum takes place.

The time at which the follicle ruptures, particularly with reference to the menstrual period, is not definite; but it is certain that while sexual excitement probably hastens the discharge of an ovum by producing a greater or less tendency to congestion of the internal organs, ovulation takes place independently of the action of coition. The opportunities for determining this fact in the human female are not frequent; but it has been fully demonstrated by observations upon the inferior animals, and there is now no doubt with regard to the identity of the phenomena of rut and of menstruation. At stated periods marked by the phenomena of menstruation, one Graafian follicle—and sometimes more than one—becomes distended and usually ruptures and discharges its contents into the Fallopian tubes. This discharge of an ovum or ova may occur at the beginning, at the end, or at any time during the continuance of the menstrual flow. Upon this point the observations of Coste seem entirely conclusive. In a woman who died on the first day of menstruation, he found a recently ruptured follicle; in other instances, at a more advanced period and toward the decline of the menstrual flow, he found evidences that the rupture had occurred later; in the case of a female who drowned herself four or five days after the cessation of the menses, a follicle was found in the right ovary, so distended that it was ruptured by very slight pressure; and other instances were observed in which follicles were not ruptured during the menstrual period.

Passage of Ova into the Fallopian Tubes.

The fact that the ova in the great majority of instances pass into the Fallopian tubes is sufficiently evident. The fact, also, that ova may fall into the cavity of the peritoneum is illustrated by the occasional occurrence of extraüterine pregnancy, a rare accident, which shows that in all probability the failure of unimpregnated ova to enter the tubes is exceptional. As regards the mechanism of the passage of the ova into the tubes, however, the explanation is difficult. At the present time there are two theories with regard

to this process; one, in which it is supposed that the fimbriated extremities of the Fallopian tubes, at the time of rupture of the Graafian follicles, become adapted to the surface of the ovaries; and the other, that the ova are carried to the openings of the tubes by ciliary currents. Neither of these theories, however, is susceptible of actual demonstration; and their value is to be judged from anatomical facts. It is not difficult to understand, taking into account the situation of the ovaries and the relations of the Fallopian tubes, how an ovum may pass into the tube, without invoking the aid of muscular action. It may be supposed, for example, that a Graafian follicle is ruptured when the fimbriated extremity of the tube is not applied to the surface of the ovary. One of the fimbriæ, longer than the others, is attached to the outer angle of the ovary and presents a little furrow, or gutter, leading to the opening of the tube. This furrow is lined by ciliated epithelium, as indeed, is the mucous membrane of all of the fimbriæ, the movements of which produce a current in the direction of the opening, which would apparently be sufficient to carry the ovum into the tube. At the same time there probably is a constant flow of liquid over the ovarian surface, directed by the ciliary current toward the tube; and when the liquid of the ruptured follicle is discharged this, with the ovum, takes the same course (Becker). This probably is the mechanism of the passage of the ova into the Fallopian tubes; and it is possible that the fimbriated extremity may be drawn toward the ovarian surface, although it is difficult to understand how it can be closely applied to the ovary and exert any considerable pressure upon the distended follicle. It is proper to note, also, that the conditions dependent upon the currents of liquid directed by the movements of cilia are constant and could influence the passage of an ovum at whatever time it might be discharged, while a muscular action would be more or less intermittent.

Puberty and Menstruation.—At a certain period of life, usually between the ages of thirteen and fifteen, the human female undergoes a remarkable change and arrives at what is termed the age of puberty. At this time there is a marked increase in the general development of the body; the limbs become fuller and more rounded; a growth of hair makes its appearance upon the mons Veneris; the mammary glands increase in size and take on a new stage of development; Graafian follicles enlarge, and one or more approach the condition favorable to rupture and the discharge of ova. The female becomes capable of impregnation, and continues so, in the absence of pathological conditions, until the cessation of the menses.

The age of puberty is earlier in warm than in cold climates; and many instances are on record in which the menses have appeared exceptionally much before the usual period. Generally at the age of forty or forty-five, the menstrual flow becomes irregular, occasionally losing its sanguineous character, and it usually ceases at about the age of fifty years. It is said that sometimes the menses return, with a second period of fecundity, though this is rare. According to most writers, while climate has a certain influence over the time of cessation as well as the first appearance of the menses, this is not very marked. When the menses appear early in life, they usually

cease at a correspondingly early period; but this is by no means constant. There are, also, many exceptions to the ordinary limits to the period of fecundity.

Although there is a periodical condition of heat in the lower animals, connected with ovulation, a sanguineous discharge from the genital organs is not often observed. It is only in monkeys that there is a counterpart of what occurs in the human female; and observations upon these animals have shown that they are subject to a monthly discharge of blood, at this time giving evidence of unusual salacity.

In the human female, near the time of puberty, there is sometimes a periodical, sero-mucous discharge from the genital organs, preceding, for a few months, the regular establishment of the menstrual flow. Sometimes, also, after the first discharge of blood, the female passes several months without another period, when the second flow takes place and the menses then become regular. In a condition of health the periods recur every month, until they cease, at what is termed the change of life. In the majority of cases the flow recurs on the twenty-seventh or the twenty-eighth day; but sometimes the interval is thirty days. As a rule, also, utero-gestation, lactation, and severe diseases, acute and chronic, suspend the periods; but this has exceptions, as some females menstruate regularly during pregnancy, and it is not very uncommon for the menses to appear during lactation.

Removal of the ovaries, especially when this occurs before the age of puberty, usually is followed by arrest of the menses. It is a well known fact that animals do not present the phenomena of heat, after extirpation of the ovaries. Raciborski has quoted cases of this operation in the human subject, in which the menses were arrested; but this rule does not appear to be absolute, as Storer has reported at least one case, in which menstruation continued with regularity for more than a year after removal of both ovaries. Thomas, in three cases of removal of both ovaries from menstruating women, which he followed for five and a half months to two years and eleven months after the operation, noted no return of menstruation; but in one case, nearly six months after the operation, the patient had "a bloody discharge from the vagina and all the symptoms accompanying the menstrual function." Other cases of this kind are on record.

When a cow gives birth to twins, one a male and the other apparently a female, the latter is called a free-martin and generally has no ovaries. John Hunter, in his paper on the free-martin, gave a full description of this anomalous animal and stated that it does not breed or show any inclination for the bull. In an examination of a free-martin, raised and killed by the late Prof. James R. Wood, in 1868, the uterus was found rudimentary and there were no ovaries (Flint).

A menstrual period presents three stages: first, invasion; second, a sanguineous discharge; third, cessation.

The stage of invasion is variable in different females. There is usually, anterior to the establishment of the flow, more or less of a feeling of general *malaise*, a sense of fullness and weight in the pelvic organs, accompanied